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Simplified Type 4 wind turbine modeling for future ancillary services

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Abstract

This paper presents a simplified generic model for a variable speed wind turbine with full scale power converter, able to reflect wind turbines dynamic features relevant for frequency control capability studies. The proposed model follows the basic structure of the Type 4 standard wind turbine model proposed by the IEC Committee in IEC 61400-27-1. Furthermore, it includes several adjustments and extensions of the standard model, in order to represent the capability of wind turbines to provide active power services during events in the power system that affect frequency. The general configuration of the simplified Type 4 wind turbine model able to account for dynamic frequency control features is described, while its performance is assessed and discussed by means of simulations.

Objectives

IEC standard wind turbines models (IEC 61400-27-1):

- suitable for fundamental frequency positive sequence response simulations during short term events
- not intended for studies with wind speed variability
- not intended for studies of wind turbines' capability to provide ancillary services like inertia control, where information on the available power is primordial

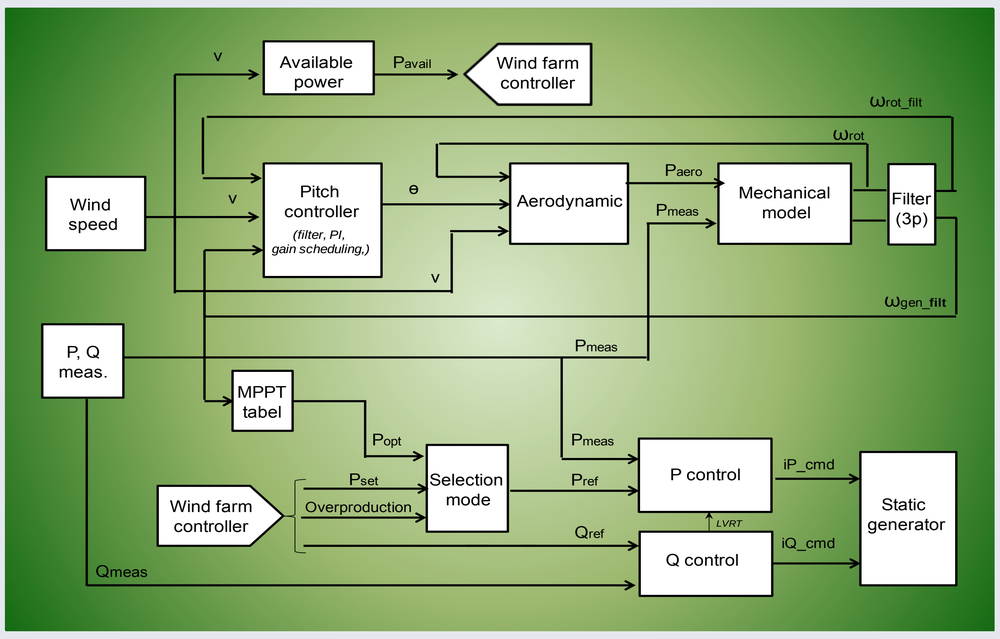
Need for simple generic wind turbine models:

- account for dynamic features of interest to primary frequency control studies
- have great relevance for integrating new frequency control functionalities corresponding to new possible ancillary services for future wind turbines:
  - Inertial response
  - Synchronizing power
  - Power system damping

Adjusted Type4B wind turbine configuration

Model's target:

- to reflect correctly the dynamic behavior of wind power output caused by i.e.:
  - wind speed fluctuations
  - changes in active power setpoints of wind turbines



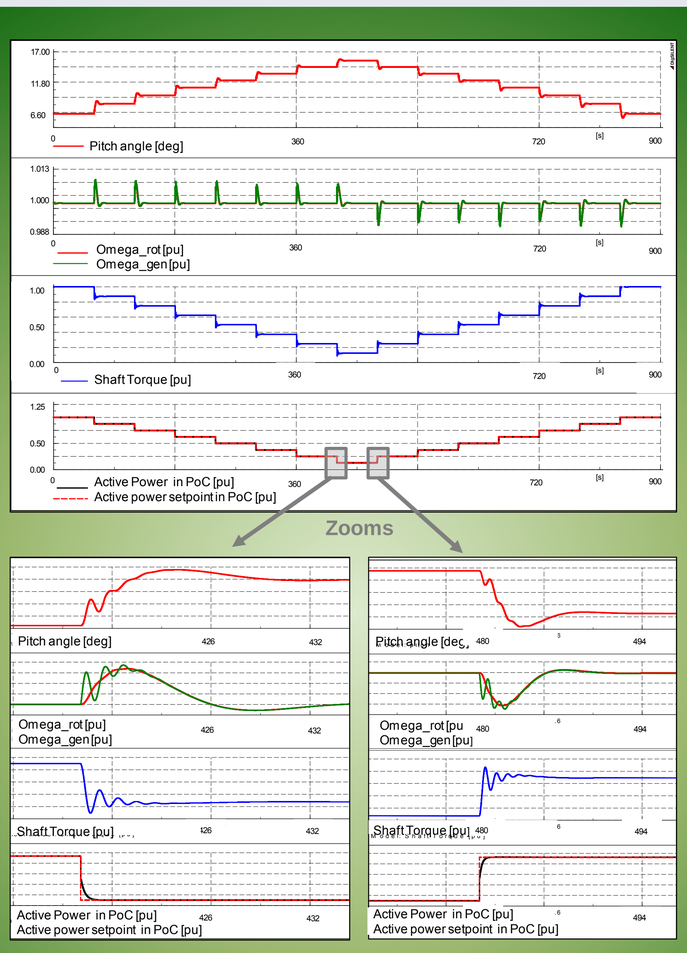
Model configuration:

- follows the basic structure of the IEC standard Type 4B wind turbine model
- includes additional adjustments and features in order to represent the power support capability of modern wind turbines, similar to conventional power plants.
- includes sufficiently detailed representation of the turbine's relevant components and control algorithms, allowing implementation of new control functionalities

Simulation results

Power support capability of the wind turbine

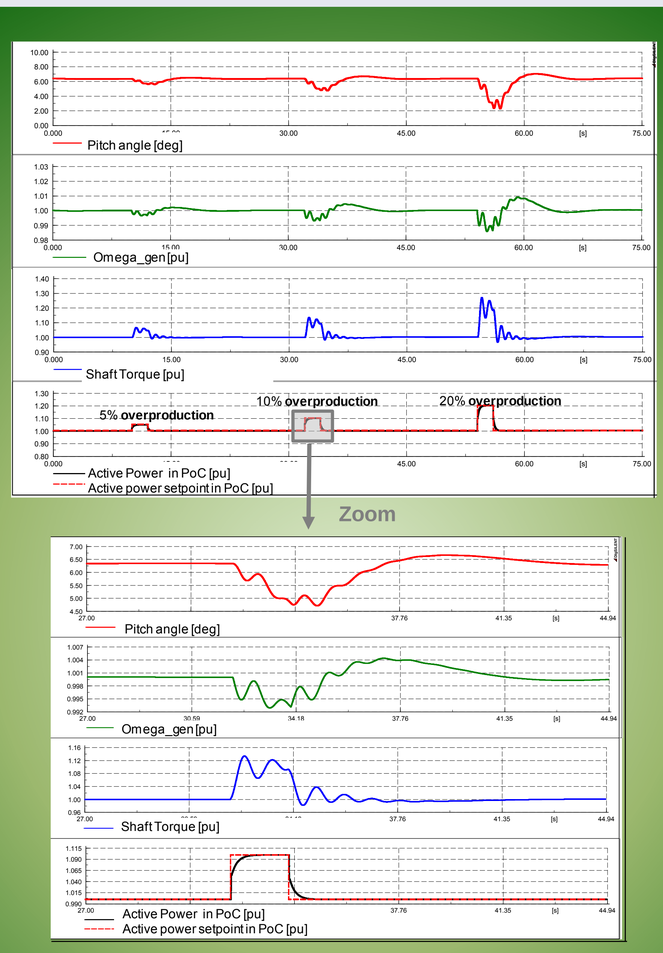
- steps in active power setpoint
- 13m/s wind speed



- active power follows its setpoints
- reduction of the active power implies an increased pitch angle
- dynamics of the generator also reflected in the shaft torque

Wind turbine's response during temporary overproduction

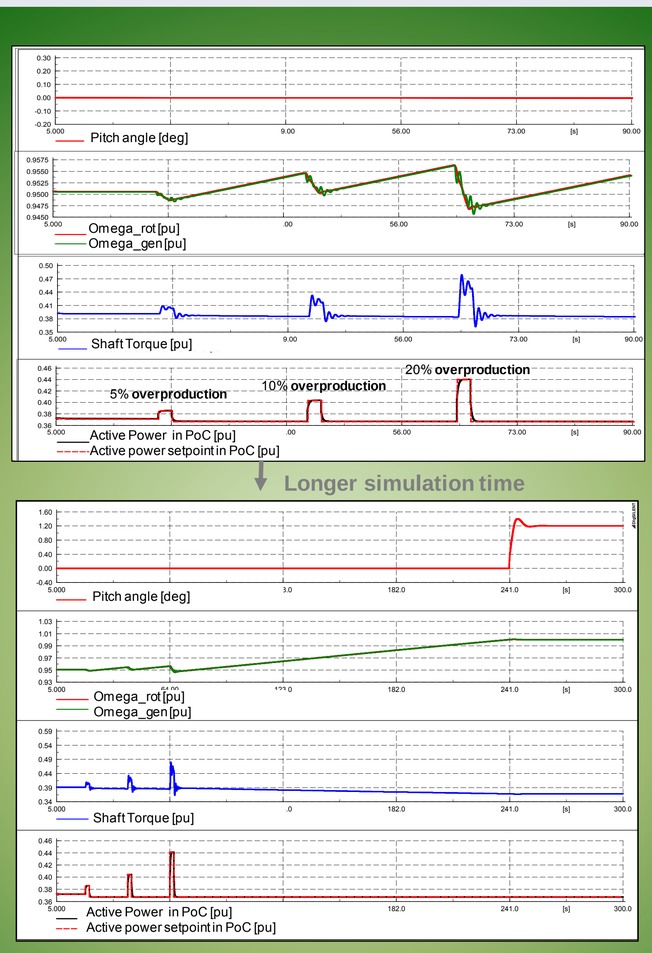
- 13m/s wind speed
- 5%, 10% and 20% during 2 sec



The higher the overproduction:

- the deeper the drop in the pitch angle
- the deeper the drop in the gen. speed
- the higher the shaft torque

- 8m/s wind speed
- 5%, 10% and 20% during 2 sec



- gen. speed decreases during overproduction
- gen. speed increases when overproduction is stopped
- gen. speed increases until it reaches its nom. value and the pitch controller is activated